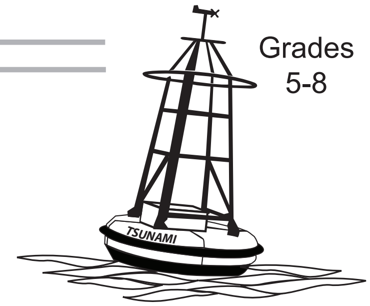
The Bottom of the Ocean



Grades 5-8

Overview:

In this lesson, students study bathymetric features of the ocean, predict how bathymetric features influence wave propagation and runup, then analyze an animation of a tsunami event.

Targeted Alaska Grade Level Expectations:

Science

[5-8] SA1.1 The student demonstrates an understanding of the processes of science by asking questions, predicting, observing, describing, measuring, classifying, making generalizations, inferring, and communicating.

[5] SA1.2 The student demonstrates an understanding of the processes of science by using quantitative and qualitative observations to create inferences and predictions.

[6] SB4.3 The student demonstrates an understanding of motions, forces, their characteristics, relationships, and effects by making waves move through a variety of media.

[7] SB4.3 The student demonstrates an understanding of motions, forces, their characteristics, relationships, and effects by describing the characteristics of a wave (i.e., amplitude, wavelength, and frequency).

[7] SD2.2 The student demonstrates an understanding of the forces that shape Earth by describing how the movement of the tectonic plates results in both slow changes (e.g., formation of mountains, ocean floors, and basins) and short-term events (e.g., volcanic eruptions, seismic waves, and earthquakes) on the surface.

Objectives:

The student will:

- observe a model of wave propagation;
- identify major bathymetric features of the Northern Pacific; and
- predict and analyze the influence of bathymetric features on tsunami inundation using the Kuril Island tsunami animations.

Materials:

- Water
- Clear, rectangular dish
- Overhead projector
- Clay (1 cm diameter x 12 cm long) + a little extra
- Map of labeled bathymetric features of the Pacific Ocean. [National Geographic Society. (1992). World ocean floors: Pacific ocean.]
- MULTIMEDIA FILE: “Kuril Tsunami Energy Flux” at the ATEP Website: www.aktsunami.org/multimedia
- MULTIMEDIA FILE: “Kuril Tsunami” at the ATEP Website: www.aktsunami.org/multimedia
- STUDENT WORKSHEET: “The Bottom of the Ocean”

Whole Picture:

The west coast of North America lies exposed to the expanse of the Pacific Ocean and the threat of tsunami inundation. One source of earthquakes and tsunamis is the Cascadia Subduction Zone. Another source of tsunamis can lie across the ocean. The Alaska earthquake of 1964 generated a tsunami that traveled across the Pacific, costing lives and millions of dollars in damage in Canada and the United States along the West coast (Noson, Qamar, & Thorsen, 1988).

A history of tsunamis exists in the oral traditions of the Quileute people, indigenous to the Northwest coast. In a story recorded by Albert Reagan, Thunderbird defeats two monstrous orcas. During the struggle, there was an enormous storm with thunderous noise. This was accompanied by “a shaking, jumping up and trembling of the earth beneath, and a rolling up of the great waters,” believed to describe an earthquake and tsunami (McMillan & Hutchinson, p. 52).

The shape of the ocean floor influences the propagation of a wave. Just as topography is a measure of elevation on land, bathymetry is a measure of water depth. Bathymetric maps reveal the surface of the ocean floor and reveal some hints about inundation. Tsunami waves traveling across the Pacific towards the west coast of North America encounter a variety of features. Along the north and eastern rim of the Pacific lie the Kuril and Aleutian trenches. Tsunami speed depends on depth, seamounts, ridges and continental shelves because these slow down the wave.

To study tsunami behavior, tsunami researchers at the University of Alaska Fairbanks created numerical models of the tsunami that was generated by an underwater earthquake in the area of the Kuril Islands on November 15, 2006. Through these numerical simulations, these researchers identified key bathymetric features that influenced the behavior of the wave and ultimately directed an substantial amount of energy towards Crescent City, California. Key bathymetric features include the Emperor Seamounts, the Hess Rise, Koko Guyot and the Mendocino Escarpment (Ridge or Fracture Zone). Although Koko Guyot is not labeled on the map suggested in this lesson, it is located east of the Hess Rise. A guyot is a seamount that has a flat-top due to erosion. The area around Crescent City, California has a history of tsunami inundation.

On the MULTIMEDIA FILE: “Kuril Tsunami Energy Flux,” the triangles represent energy vectors, or the direction in which energy flows. The “hotter” the color, the greater the amount of energy. This animation shows how Koko Guyot and the Hess Rise redirect energy so that Crescent City receives two major pulses of energy. The MULTIMEDIA FILE: “Kuril Tsunami” includes the location of significant features identified by tsunami researchers.

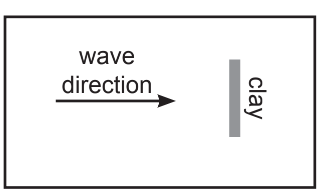
Activity Preparation:

Place a clear dish on an overhead projector. Fill with water to less than 1 centimeter depth.

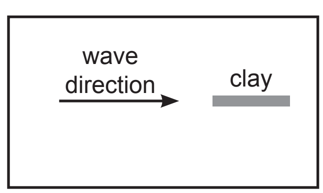
Activity Procedure:

1. Explain that students will explore how bathymetric features can influence tsunami wave propagation and inundation. Bathymetry is a measure of water depth. Bathymetric maps of the ocean display features rooted on the ocean floor. Share information from the first two paragraphs of Science Basics.

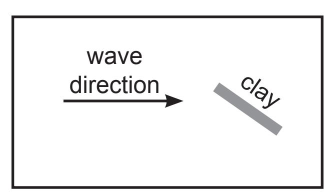
2. As a model, demonstrate wave propagation in the clear dish on the overhead projector. Ask students to observe closely as you create a wave with (1) no obstructions in the glass dish, (2) an elongated obstruction (the piece of clay) perpendicular to the wave, (3) an elongated obstruction parallel to the wave, and (4) an elongated obstruction at an angle to the wave [see diagrams 2(2)-2(4), below]. Discuss the results and repeat as necessary.



2(2) clay obstruction perpendicular to wave



2(3) clay obstruction parallel to wave



2(4) clay obstruction at an angle to wave

3. Divide students into groups and distribute a map of labeled bathymetric features, such as World ocean floors: Pacific Ocean by the National Geographic society. Guide groups in exploring features of the map such as unit of depth (meters) and features (trenches, continental margins, sea mounts, ridges, etc.). Ask students to determine the major features of the North Pacific.

4. Distribute STUDENT WORKSHEET: “The Bottom of the Ocean.” Tell students they will need to apply what they know of wave propagation and the features of the North Pacific to make a prediction of how the tsunami will travel across the Pacific and impact the West coast of North America. Review the directions on the worksheet and instruct students to complete on their own. The map of the Pacific Ocean floor should be available for reference.

Extension Ideas:

- Explore the actual location of inundation, which includes Crescent City California, on Google Earth and/or the Internet. View the runup history of Crescent City by accessing the NOAA/WDC Historical Tsunami Database at NGDC (http://www.ngdc.noaa.gov/hazard/tsu_db.shtml). Select Tsunami Runup Search and type in “Crescent City” as the Runup Location Name, then click “Search Database.”
- Repeat the process of looking at a map and predicting the influence of bathymetric features on propagation and inundation using other tsunami animations. The NOAA Center for Tsunami Research has MOST Model animations of actual Tsunami Events (http://nctr.pmel.noaa.gov/animate.html).

Answers:

Hypothesis: Answers will vary, but should include features like the Emperor Seamounts, Hess Rise, Hawaiian Islands, Northeast Pacific Basin or Mendocino Ridge to make a prediction of how the wave will travel from the Kuril Islands.

Analysis of Data:

1. Answers will vary, but should describe how the features listed above influenced the wave.
2. 2

Conclusion:

1. Answers A-D (in any order): Emperor Seamounts, Koko Guyot, Hess Rise, Mendocino Escarpment or Mendocino Fracture Zone
2. Answers will vary.

Lesson Information Sources:

McMillan, A. D. & Hutchinson, I. (2002). *When the mountain dwarfs danced: Aboriginal Traditions of paleoseismic events along the Cascadia subduction zone of western North America*. Ethnohistory. 49 (1), 41-68.

Noson, Qamar, & Thorsen. (1988). *Washington State Earthquake Hazards*. Washington Division of Geology and Earth Resources Information Circular 85.

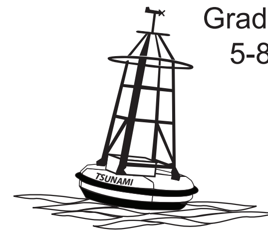
The Tsunami Research Group. (2007). *The Kuril Islands Tsunami of November 2006*. *Energy Flux Tool.* Institute of Marine Science, University of Alaska Fairbanks. Retrieved October 21, 2008 at http://www.sfos.uaf.edu/tsunami/energy_flux/index.html.

The Tsunami Research Group. (2007). *The Kuril Islands Tsunami of November 2006. Impact at Crescent City by distant scattering*. Institute of Marine Science, University of Alaska Fairbanks. Retrieved October 21, 2008 at http://www.sfos.uaf.edu/tsunami/kuril_distant/index.html

Name:___________________________

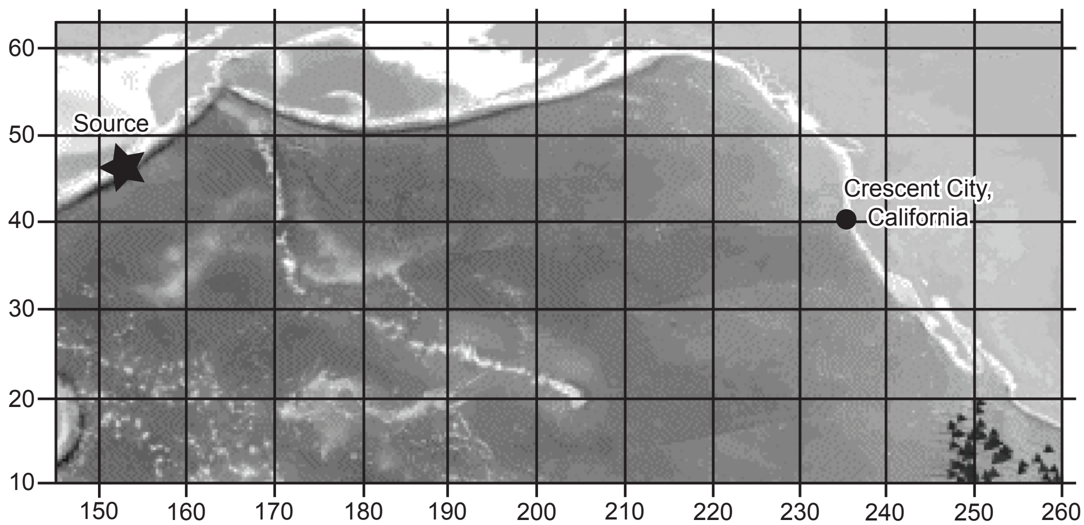
The Bottom of the Ocean

Student Worksheet (page 1 of 2)



Grades 5-8

Background Information: The image below represents the beginning of an animation developed by tsunami researchers to understand how bathymetric features affect the flow of energy. This is modeled after the tsunami that happened on November 15, 2006, which began in the Kuril Islands.



Hypothesis:

Use the map of the Pacific Ocean floor to write a prediction of how the bathymetric features of the North Pacific would influence the propagation of the tsunami generated in the Kuril Islands. Consider the location of generation, and how that will affect the inundation of the west coast of North America.

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Procedure:

View the MULTIMEDIA FILE: "Kuril Tsunami Energy Flux" at www.aktsunami.org/multimedia. The direction of the flow of energy is represented by arrows and the "hotter" colors note higher levels of energy. Replay this animation as necessary.

Name:______________________________

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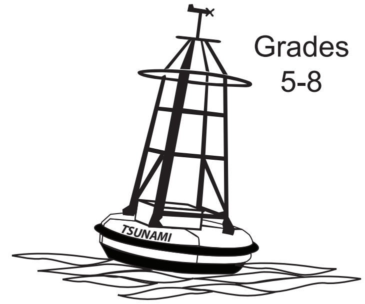
Student Worksheet (page 2 of 2)



Grades 5-8

Analysis of Data:

1. Describe how the bathymetry affected the wave propagation.

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2. How many major groups of waves reached Crescent City, California?____________________

Conclusion:

View the MULTIMEDIA FILE: “Kuril Tsunami” at the ATEP Website: www.aktsunami.org/multimedia. In this animation, scientists identified the major bathymetric features affecting the propagation of the tsunami generated in the Kuril Islands. One of the identified features is called Koko Guyot. A guyot is a seamount with a flat-top. Koko Guyot is west of Hess Rise. The points labeled DART are buoys. Replay this animation as necessary.

1. List the four features that impact the propagation of the wave.
   A. ____
   B. ____
   C. ____
   D. ____

2. How did your prediction compare to the animation?

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